A Taxonomy Characterizing Complexity of Consumer eHealth Literacy

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Abstract

There are a range of barriers precluding patients from fully engaging in and benefiting from the spectrum of eHealth interventions developed to support patient access to health information, disease self-management efforts, and patient-provider communication. Consumers with low eHealth literacy skills often stand to gain the greatest benefit from the use of eHealth tools. eHealth skills are comprised of reading/writing/numeracy skills, health literacy, computer literacy, information literacy, media literacy, and scientific literacy [1]. We aim to develop an approach to characterize dimensions of complexity and to reveal knowledge and skill-related barriers to eHealth engagement. We use Bloom's Taxonomy to guide development of an eHealth literacy taxonomy that categorizes and describes each type of literacy by complexity level. Illustrative examples demonstrate the utility of the taxonomy in characterizing dimensions of complexity of eHealth skills used and associated with each step in completing an eHealth task.

Introduction

eHealth is an emerging subfield within medical informatics that develops information and communication technology tools and applications for use in healthcare [2]. Within eHealth are consumer-oriented tools designed to engage consumers in managing their own health care, communicating with providers and social networks, and meeting their information needs [3]. Some examples of consumer-oriented tools are patient health records, health information web sites or portals, telemedicine applications, online social support groups, interactive behavior change tools, decision support systems, and tools that support chronic disease self-management [4]. Pew Internet Project data reveals that 75-80% of internet users are turning to online resources for health information [5]. There is great potential for eHealth interventions to promote and support patient health by providing health information, engaging the consumer in monitoring and managing their health, augmenting patient-provider communication, and aiding decision making about health issues.

According to Eysenbach's "inverse information law", access to information is often most difficult for those who need it most [6]. Those in resource poor settings and with low eHealth literacy skills face the greatest challenges in accessing health resources and in managing their health, but also stand to realize greater benefits from eHealth. eHealth disparities result from three main factors: physical access, resources, and knowledge and skills [4]. Further exploration and understanding of these barriers can inform design and development of eHealth interventions. Specifically, understanding the knowledge and skills required to interact with eHealth tools can inform the need for mediating interventions such as educational initiatives, design and development guidelines, and evaluation heuristics. Few research efforts have used a systematic approach to analyzing barriers across eHealth interventions. In this paper, we present an approach to characterize dimensions of complexity and to reveal skill and knowledge barriers to engaging in and benefitting from eHealth, across a variety of health domains and technologies.

eHealth Literacy

eHealth literacy encompasses the set of knowledge and skills that allow consumers to fully engage in and benefit from these eHealth tools. We adapt the eHealth Literacy Model which describes six facets of eHealth literacy [1], each of which is necessary to engage in and benefit from eHealth applications:

- *Computer Literacy* describes the skills to use computers to solve problems. These skills span a wide range from basic knowledge such as how to open a browser window to developing computer applications.
- *Information Literacy* encompasses the skills to articulate information needs, to locate, evaluate, and use information, and to apply information to create and communicate knowledge [7].
- *Media Literacy* is the ability to select, interpret, evaluate, contextualize, and create meaning from resources presented in a variety of visual or audio forms [8]. This also includes the ability to assess privacy and security of different resources.
- *Traditional Literacy and Numeracy* encompasses reading and understanding written passages, and speaking and writing a language coherently [1]. Numeracy is comprised of quantitative skills and the ability to use information artifacts such as graphs, scales, and forms [9].
- *Scientific Literacy* includes familiarity with basic biological concepts and the scientific method as

well as the ability to understand, evaluate, and interpret health research findings using appropriate scientific reasoning [10].

- *Health Literacy* supports effective participation in the health care process. Familiarity with health vocabularies, and acquisition, evaluation, and appropriate application of relevant health information allows consumers to communicate about health, make health decisions, and utilize health services [11].

Levels of cognitive complexity

Bloom's Taxonomy is a well-known taxonomy to classify levels of intellectual behavior in learning. It has been adapted and applied to different research areas within health and technology, such as for computer-based training in medicine [12]. In 2001, it was revised into a two-dimensional representation of knowledge and cognitive processes.

The revised taxonomy consists of six cognitive process dimensions that increase in complexity and cut across factual, conceptual, procedural, and meta-cognitive knowledge. These six dimensions are defined as [13]:

- *Remembering* is retrieving, recognizing, and recalling relevant knowledge from long-term memory.
- *Understanding* includes constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, summarizing, classifying, inferring, comparing, and explaining.
- *Applying* involves using knowledge to execute a procedure.
- *Analyzing* comprises breaking material into constituent parts, and determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing.
- *Evaluating* involves making judgments based on criteria and standards.
- *Creating* consists of putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.

The six facets of eHealth literacy operate in an interactive network when carrying out eHealth tasks using a technological tool. In this paper, an eHealth task refers to the use of a technology application to complete a health-related activity (such as finding health information or monitoring health status). The technological tool can be any application, such as an interactive health website, a personal health record, or a health information kiosk. The systematic categorization of eHealth literacy classifies the complexity and highlights the role of each eHealth literacy of each step to complete an eHealth task, and provides a structure to their configurations and interactions in relation to different types of tasks. This breakdown of literacies and tasks helps reveal and better understand the literacy-specific barriers to eHealth engagement.

Method

We first sought to characterize and describe the different levels of complexity within each of the six facets of eHealth literacy. Bloom's taxonomy was found to be the best fit for characterizing complexity as it provides an additional level of analysis for understanding dimensions of eHealth literacy, allowing study of cognitive function as well as knowledge and skill. The taxonomy is structured as a matrix; the six facets of eHealth literacy are along one axis, and the six levels of complexity are along the other axis, resulting in 36 combined categories.

Through an iterative process of review and adaptation, evidence from peer-reviewed articles discussing eHealth and each type of literacy informed development of definitions that describe each of the 36 combined categories. One example of a combined category is the "Remembering" in computer literacy category which describes knowledge of a computer and its associated components (such as keyboard, mouse, and monitor). An example of a moderately complex category is the "Applying" in health literacy category, which is the ability to use health information appropriately. This may take the form of following directions to engage in appropriate self-care activities, such as following therapeutic regimens. An example of the highest category of complexity is the "Creating" in information literacy category which describes the ability to apply found information to create and communicate knowledge, for example to create a blog.

We use three illustrative examples to demonstrate how the taxonomy can characterize necessary eHealth skills for completing a task. There are three information seeking tasks in separate health domains that draw on different sets of reasoning and interpretation skills. Tasks 1 and 2 were drawn from video data of a training session of older adults learning to use MedlinePlus to find health information [14], and Task 3 is from a study of older adults using the Medicare.gov website to carry out health tasks [15].

For each task, two researchers (CC and LM) listed the steps used to complete the specified task, identified the skills and knowledge required to complete each step, and then identified the eHealth literacies and complexity level of each literacy used to complete that step. A step may require multiple facets of eHealth literacy. The steps and knowledge were elicited using a combination of methods: 1) extracting observations and dialog from the video data, and 2) cognitive task analysis (CTA). CTA is a useful method to study and characterize knowledge, skills, and usability issues in the interaction between a user and a technology [16]. Each researcher independently analyzed each task, then discussed results together to reach consensus.

Example task 1
The first example task is to navigate to the MedlinePlus website (www.medlineplus.gov) and find an informational resource about Asthma.

Example task 2
The second example task requires more steps and additional knowledge: Using MedlinePlus, find the answer to the question "What medications or treatments are used for arthritis?" using a different navigation pathway from the previous example task.

Example task 3
The third example requires a short series of reasoning steps. The task is to use the Medicare website (www.medicare.gov) to locate the 3 closest dialysis centers in a given neighborhood, then compare the 3 dialysis centers and select the facility with the highest percentage of patients with anemia under control.

Results

Analysis of the three tasks yielded a step-wise representation of eHealth literacy for each task, making possible a comparative analysis of eHealth configurations within and across the tasks. Task 1 was completed over a total 12 steps. An excerpt of the coding results is shown in Table 1. Step 1 required only computer literacy. Most steps required a combination of two eHealth literacies. Step 5 required the highest combination, four eHealth literacies. In this step, the MedlinePlus website provides an abundance of resources and the ability to recognize the variety of resource categories and segment the homepage into relevant categories is an essential, yet potentially overwhelming process to a novice computer user. Similar analysis was done for all three tasks.

The summary results of eHealth literacy used to complete the three example tasks is displayed in Table 2. For task #1, computer literacy was used the most often (5 of 12 steps), and the highest level of complexity used was information literacy (level V). For task #2, computer literacy was used most often (15 of 22 steps), and the highest level of complexity used were in information literacy, reading literacy, and media literacy (level V). For task #3, reading literacy was used most often (25 of 29 steps), and the highest level of complexity used were in information literacy and numeracy (level V). Task 2 was the only task to require scientific literacy, which was used to recognize and differentiate biological concepts pertaining to arthritis. Task 3 required the highest complexity level of numeracy, during steps involving understanding and extracting information about anemia measures from graphs. All three tasks required at least one eHealth literacy at complexity level V. None of these three tasks engaged the most complex of skills. Task 2 required complexity of at least level II, and required three eHealth literacies at level V suggesting that Task 2 may be most complex among the three tasks and may pose difficulty to eHealth consumers. Information literacy was required at level V complexity for all three tasks, suggesting that information literacy is an essential skill in order to complete any of these tasks, and that this would be

Step #	Skills and knowledge required	eHealth literacy and complexity level required
1	Open internet browser	Computer III
2	Navigate to www.MedlinePlus.gov	Computer III Reading I Writing I
3	Verify that you have navigated to the correct website, and that it is health-related	Media II Reading I
4	Identify the source of the information on the website and evaluate the credibility and trustworthiness of the website	Media III Reading II
5	Segment the homepage into sections: topic areas and resources in left column, news and features in middle column, and interactive and educational resources in right column	Computer III Information II Reading I Media II
6	Articulate information need: find informational resource about asthma	Information II Health I
By increasing complexity: I=Remembering, II=Understanding, III=Applying, IV=Analyzing, V=Evaluating, VI=Creating		

Table 1. The skills and knowledge identified in the first 6 of 12 total steps of task 1 are coded with eHealth literacies and complexity levels.

	Example task #			
eHealth literacy	#1	#2	#3	Total # each literacy
Media Literacy	3 III	4 V	1 III	8
Computer Literacy	5 III	13 IV	15 III	33
Health Literacy	4 I	8 IV	6 IV	18
Information Literacy	4 V	8 V	12 V	24
Reading Literacy	9 II	17 V	25 III	51
Writing Literacy	1 I	2 III	1 I	4
Numeracy	0	2 II	5 V	7
Scientific Literacy	0	3 III	0	3
Total # steps per task	12	22	29	
By increasing complexity: I=Remembering, II=Understanding, III=Applying, IV=Analyzing, V=Evaluating, VI=Creating				

Table 2. For each task, the following is displayed: the total number of times the eHealth literacy was utilized (numbers in top half of cell) and the highest level of complexity used in that literacy (roman numerals in bottom half of cell).

a useful skill to promote among health consumers. Writing literacy was required at level I complexity for two tasks, most likely because these were all information-seeking tasks which do not demand much communication of knowledge.

Reading literacy was used most often across all three tasks (51 times), which highlights the heavy reliance on reading literacy to complete any of these tasks. Scientific literacy was used least often (3 times), and only for one task. While it may have been least frequently used, it was nonetheless essential to completing task #2.

Discussion

This taxonomy can be a useful analysis tool to create illuminating representations of tasks. The analysis, as illustrated in Table 1, displays the configuration of eHealth literacy utilized to complete each step of the task. The representation also portrays how the different eHealth literacies interact with each other, and if applied to a wider range of tasks, can begin to inform the relationships between and among the different eHealth literacies. Applying this analysis to a greater number of tasks can also help to identify those knowledge and skill sets that are most often required, and which are most often required at higher levels of complexity, across health domains and across technologies. The analysis as presented in Table 2 shows the breakdown of a task into the elements of knowledge and skills required and the complexity levels required; this analysis can be used to identify the root cause of difficulty for a health consumer. These analyses can inform the need for and development of appropriate guidance and education tools to facilitate consumer use of eHealth. Applying this taxonomy to analyze consumers' interaction with eHealth tools can reveal specific barriers at certain steps of a task. These analysis metrics can inform calibration of tools to match the knowledge and skills of potential users and of target populations. The analysis could also provide predictive potential of a user's performance on a task, based on the similarity between their eHealth literacy level and the dimensions of complexity required by the task.

Conclusion

eHealth is an emergent field that has great potential to transcend barriers in providing access to better healthcare, but given impediments caused by low literacy, could also contribute to the exacerbation of health disparities. A systematic approach to understanding barriers to engagement can inform development of applications that would include those with lower eHealth literacy. The advent of more interactive functionalities online, such as social networking platforms, furthers the need to understand the skill and knowledge requirements to participation.

The characterization of eHealth literacy used in completing a task can reflect usability and design properties of the technology tool. The knowledge and skills measured and successful completion of the task reflects the consumers' functional ability to adapt to different tools and navigate obstacles. Those tools that are more difficult to manipulate and navigate may be reflected in the use of more complex levels of knowledge and skills to complete a task using that tool. However, the taxonomy is not a tool for studying usability issues, and cannot characterize all the obstacles encountered while using that tool.

This taxonomy focuses specifically on the knowledge, skill, and cognitive aspects of engagement barriers. There are a wide range of social, psychological, environmental, and emotional barriers to eHealth use, including attitudes, access, and appropriate content. These are important dimensions and need to be considered in a more inclusive analysis of barriers. The analysis of the three examples is not provided to comprehensively validate the taxonomy, but to show proof of concept for the viability of our approach. It is important to note that this is formative work, and the taxonomy is provisional and subject to validation.

Future research will apply this analysis with observation of human subjects performing identified eHealth tasks. This will explore applicability of this taxonomy with participants and can serve as a validation step for the taxonomy. Empirical analysis can also reveal whether the acquisition and execution of eHealth skills progresses in a linear progression of complexity, or in a different pattern. The application domain of a task may affect complexity of a task. For example, the "Applying" skill may be more challenging in the context of task #2 as compared to tasks #1 or #3. Empirical analysis can reveal these differences across tasks and health domains.

We have developed a taxonomy of eHealth literacy, categorized and described by complexity. The taxonomy can inform deeper understanding of eHealth literacy that spans a range of health domains and technology applications, and can reveal knowledge and skill barriers to participation and engagement. The three illustrative examples employ information seeking tasks with non-interactive websites. The taxonomy and analysis methodology can also be applied to analyze different technology applications, such as interactive applications, personal health records, decisions support tools, and disease self-management tools, to explore applicability with those functionalities. Wide application of the taxonomy can elicit generalizeable understanding about eHealth literacy among a variety of health domains and technologies. The details and barriers revealed by applying this taxonomy to analyze eHealth tasks can inform the development of design guidelines of tools, evaluation heuristics, eHealth literacy assessment, and educational objectives to increase consumer eHealth skills. In particular, this taxonomy and analysis methodology can be used with health consumers with low eHealth skills to better understand barriers, and to develop educational media or other mediating tools to facilitate engagement with and benefit from eHealth.

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